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Using "Clickers" in the Classroom to Increase the Level of Student Interaction

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September 2008

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Interaction is crucial in classrooms because increased interaction is linked to increased learning. Past studies report that students learn by a myriad of methods, and that it is up to the instructor to promote as many means as possible to transport the material to the students. One way in which instructors are providing information to their students is through a classroom response system (CRS), an electric transponder the size of a remote control. The CRS allows users to respond and interact with the push of a button.

This study looked at educational institutions using CRS, in order to identify the distinctive characteristics that are analyzed to value its effectiveness in a classroom environment. The information collected was examined to gain an understanding of the various uses of CRS to determine if they would be a beneficial addition to resident NPS curriculums.

Also, this study employed a posttest-only independent group quasi-experimental design to test the effects of clickers in the classroom. Specifically, clicker use was studied to determine what impact, if any, their use would have on student interaction in the classroom, student engagement, student motivation, perceived teacher immediacy, course liking, and students' overall evaluation of the clickers. The findings and implications of this study are discussed.

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USING "CLICKERS" IN THE CLASSROOM TO INCREASE THE LEVEL OF STUDENT INTERACTION

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USING "CLICKERS" IN THE CLASSROOM TO INCREASE THE LEVEL OF STUDENT INTERACTION

ABSTRACT

Interaction is crucial in classrooms because increased interaction is linked to increased learning. Past studies report that students learn by a myriad of methods, and that it is up to the instructor to promote as many means as possible to transport the material to the students. One way in which instructors are providing information to their students is through a classroom response system (CRS), an electric transponder the size of a remote control. The CRS allows users to respond and interact with the push of a button.

This study looked at educational institutions using CRS, in order to identify the distinctive characteristics that are analyzed to value its effectiveness in a classroom environment. The information collected was examined to gain an understanding of the various uses of CRS to determine if they would be a beneficial addition to resident NPS curriculums.

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I. BACKGROUND AND LITERATURE REVIEW

A. CHAPTER OVERVIEW

The purpose of the case study is to look inside educational institutions that are using classroom response systems (CRS) and identify the distinctive characteristics that are analyzed to value its effectiveness in a classroom environment. The goal is to gain an understanding of the various uses of CRS to determine if they are worth implementing into resident NPS curriculums. This chapter answers the question: what are CRS? It then describes their general characteristics, examines the motivations for their use, and summarizes the more popular models available on the open market.

This chapter first defines CRS by breaking down and describing the individual components that make up the CRS. CRS have also been referred to as personal response systems, classroom communication systems, group response systems, electronic voting systems, audience paced feedback systems, classroom network systems, and audience response systems. Second, this chapter explores why CRS are used in institutions by delving into the historical developments and outlining the different environments in which they are used. Third, this chapter references case studies from institutions that used CRS in large classroom environments (e.g., West Virginia University, Wayne State University, Surrey University, Eastern Washington University, and Ohio State University), in order to discuss methods in which they statistically proved the effectiveness, typical uses, and characteristics of CRS. Finally, this chapter compares and analyzes five CRS from the most popular and commonly used CRS manufacturers.

In the past couple of years, large advances in CRS have been made in both technology and popularity. The Naval Postgraduate School (NPS) mission statement states that NPS "provides relevant and unique advanced education…" (Registrar, 2007). Operating on the cutting edge of technology, NPS has recently implemented the use of CRS into their Executive Management curriculum to provide a more unique and advanced education. Always striving for technological and educational improvements, the NPS Graduate School of Business and Public Policy is experimenting with the use of the Renaissance Classroom Response System. The results from analyzing case studies are used to formulate the methodologies for CRS research study (Chapter III), which is used to test and evaluate the level of student interaction with CRS in resident NPS curriculums.

B. DESCRIPTION OF CLASSROOM RESPONSE STYSTEMS (CRS)

1. CRS Overview

Simply stated, the handheld devices in classroom response systems (CRS)—commonly known as “clickers” or “key-pads” in the United States and “handsets” or “zappers” in the United Kingdom (Barber & Njus, 2007)—are electronic transponders about the size of a television remote control. Each clicker allows the user to respond by the push of a button. The clicker is only one of three components that make up the CRS. The second component is the receiver, which is typically connected to the professor’s computer. The receiver collects responses from the clickers. Finally, the third component of the CRS is the associated software. Associated software packages allow professors to create questions, send notes and receive clicker responses so they can be displayed for review. A further breakdown of three CRS components should be helpful in understanding why clickers are used.

2. Description of Clickers

Clicker handsets come in a variety of shapes, colors and sizes, and have various functionality differences. In a standard classroom environment, each student will have one clicker. Due to equipment limitations, students may have to share. Depending on the manufacturer and model, clickers vary in size. They can be as small as a credit card or as large as an old style television remote control.

Early models of clickers had a single response button (Poulis, Masen, Robens, & Gilbert, 1998), while modern clickers usually have a 10-digit numeric keypad and often some accessory buttons including a power switch, a send button, or function keys that permit text entry (Barber & Njus, 2007). Early models only allowed students to respond to yes/no, true/false or A/B types of questions. These older models also had a wire that connected the clickers to the receiver. The advantages to the simplicity of earlier models are that "they required little effort to understand the system, there was no possibility of the wrong button being pressed, and they caused minimal disruption and distraction when used" (Poulis et al., 1998). The primary disadvantages were that, if students had to answer more than one question, response options had to be manually entered sequentially, preventing the user from skipping a question and returning to it later. Additionally, earlier models only provided one-way communication, meaning students could send their responses but there was no indication of whether the response was received.

Aside from having the luxury of being wireless, modern clickers have many more capabilities through their multi-button keypads. Not only can they answer the simple yes/no questions, modern clickers enable students to answer multiple-choice questions and express confidence levels in the accuracy of their answers, which is helpful in analyzing whether correct answers were chosen through luck or based on knowledge (Simpson & Oliver, 2006).

Each clicker has an assigned ID number that allows professors to map ID numbers to individual students. This feature can be helpful if professors want to keep the identities of student responses confidential or, conversely, use them for analysis. For example, if professors chose to use clickers to facilitate graded quizzes, assigned ID numbers would allow them easily to tally and record quiz results. Finally, at the end of the class, depending on the situation, if professors needed to collect the clickers for redistribution in another class, assigned ID numbers would help with accountability.

The most modern wireless clicker models, such as the Renaissance CRS (which will be used in this case study), have LCD screens that can be used to view transmitted text. LCD screens are useful because they allow students to read questions at their own speed. Professors can send notes in addition to quiz questions which can be stored in the clickers' memory and viewed on the LCD screens. Additionally, LCD screens allow students to return and review answers in multiple question quizzes. Having clickers with LCD screens frees up a media asset in the classroom. Now, professors can use the clicker LCD screens vice writing questions on the blackboard or posting them on a projection screen.

3. Description of Receiver

Clickers transmit data to the receiver using radio frequency (RF), infra red (IR), or through a wire, depending on the type of CRS. Receivers are typically connected to the professor's personal computer (PC) through a USB port. They are responsible for capturing responses from clickers and transmitting information sent by the professor such as assignment questions, quiz questions, and notes.

The word "receiver" is a misleading term for the name of the receiver component in a CRS. The *American Heritage Dictionary of the English Language* defines "receiver" as a device or apparatus that receives electrical signals (Berube, 2006). For early CRS models, receiver was an appropriate name because these early models operated using one-way communication. Data were transferred from the clicker and received by the receiver through a wire that connected the two components.

Modern CRS use two-way communication. The receiver receives data from the clickers and transmits responses in return. Therefore, a more appropriate descriptive name for modern receivers would be transceivers. "Transceiver" is defined by the *American Heritage Dictionary of the English Language* as a transmitter and receiver housed together in a single unit and having some circuits in common, often for portable or mobile use (Berube, 2006). For the purpose of this case study, the term "receiver" will be used when referring to the receiver component of the CRS.

Wireless clickers operate using one of two technologies, RF or IR. RF systems are rapidly becoming the current standard because they have greater range, send stronger signals, require only a single receiver, do not experience interference from classroom lights or other IR-emitting equipment and do not require a direct line of sight between the student and the receiver (Caldwell, 2007). Until recently, clickers using RF signals have always been better suited for large audiences, but their high cost prohibited widespread application. However, all major CRS vendors have now introduced low-cost RF keypads, and many vendors have already discontinued their old IR models (Barber & Njus, 2007). As technological advances lower the cost of electronics, IR systems are being phased out and replaced by the more capable RF clickers.

Receivers do have their limitations, depending on manufacturer make and model. For example, the Reply system, which uses RF, needs only one receiver for up to 650 clickers. The PRS system, which uses IR, needs one primary receiver for the first 50 students and a secondary receiver for every additional 35 students (Simpson & Oliver, 2006). The added reliability, reduced cost, and increased functionality of RF systems have made CRS more practical to use in educational institutions across the nation.

4. Description of Associated Software

Each CRS comes with an associated software package. Software packages have to be loaded on each PC that will be used as a host for the connected CRS receiver. Due to modern IT restrictions, it may be necessary to contact the IT department and get permission to load software on school computers, and also to ensure the host's PCs meet CRS software requirements. Most software systems are said to be easy to use with only an "intermediate" level of computer skill, thereby freeing the professor to consider pedagogy rather than technical operations (Brewer, 2004). User-friendly software shortens the training time required for professors to implement CRS into their classrooms, making the technology more appealing. Furthermore, easy-to-use software minimizes fear and stress caused by resistance to change.

Among the variety of software packages, two characteristics emerge in the more commonly used CRS. First, once the receiver collects the data from the clickers, the software compiles and evaluates the responses, making them available for display to the class using some type of projection device. Responses can be displayed graphically as a list, table, histogram, bar-chart, or simple percentage. Secondly, software allows professors to create, format, and display questions.

In addition to the two most common characteristics, software applications can be used by professors to perform more advanced functions, such as selecting which answers are correct and assigning weights to graded responses. These functions are typically referred to as grading tools. More complex software packages allow for real-time cross tabulation, making it possible to compare responses between two questions, such as pre- and post-test questions, or to group responses by demographic variables. These results can be saved and used by professors for grading or further evaluation after class (Kaleta & Joosten, 2007). Another example, the PRS software can record information, including the number of attempts made, the time taken to register the answer, and the confidence levels. These results can be saved and used later, employing standard software such as Microsoft Office to view the results (Simpson & Oliver, 2006).

Before prematurely buying the first CRS that captures the buyer’s attention, conduct a little research to ensure that the associated software package that comes with the CRS will be able to perform the required functions. Although manufacturers typically have additional software packages for sale that may suit the educational institution’s needs, these software packages are largely dependent on the type of system purchased. Additional software package options may be limited. The primary drawback is that CRS only work with the software applications designed for each specific system. Thus, if some someone were to purchase a CRS that did not have the specific features required, the only solution would be to purchase a different CRS system.

C. EVOLUTION OF CRS AND THEIR ENVIRONMENT

1. Historical Overview

The Greek philosopher Socrates was a master at pedagogy. He realized that people understand more by answering a question than by being told an answer (Abrahamson, 1999). An amazing revelation, even in this modern day and age, is that society can turn back to seek wisdom from a man who lived 2400 years ago. This ancient wisdom is familiar to any parent today: as a father sits at the kitchen table watching his daughter do her homework, she looks over to him and asks for help with a simple math problem. The father knows that answering the question would be simple, but doing so would deprive the daughter of the satisfaction of figuring out the answer herself.

The reason that the Socratic Method works in teaching is because a teacher, through questioning, can spotlight an area of knowledge, encourage students to think through the issues, establish positions, and commit to positions (Abrahamson, 1999). Professors asking the right questions at the appropriate moments stimulate thought processes. Taking stimulated thought processes and providing rapid feedback can reinforce this loop (Simpson & Oliver, 2006).

The main problem with Socratic teaching is that it works well in small groups of five or fewer students, but in larger classroom environments the majority will be left out of the interaction experience (Abrahamson, 1999). Typically, professors can establish a one-on-one dialogue with only a few students in a large classroom during any given lecture, due largely to lecture time constraints. Educational institutions clearly need to find innovative ways of keeping dialogue channels open between the professor and students. This challenge is becoming more difficult as the world's population grows, resulting in larger class sizes (Bartlett, 1998).

2. CRS Environment

In modern times, ensuring that everyone has a chance to receive an education is made possible by using much larger classroom environments. The method of teaching is quite different from years past, when the rich were the only individuals who received an education (Abrahamson, 1999). So, using the best teaching methods would only be appropriate. The tutorial system at Oxford and Cambridge in England, where two to five students meet regularly with their professor ("tutor") in his or her study is an excellent example of an active learning environment. This is clearly a wonderful environment for teaching and learning, but it is expensive—much more expensive than a big class or lecture. This was the reason behind the CRS (Abrahamson, 1999). CRS were designed as a practical solution to increased classroom sizes. Although smaller classes would be better, CRS attempt to bridge the gap between the lack of teacher-student interactions in large classrooms and build a better learning environment.

In a perfect world, searching for different methods of teaching would not be necessary. The passive traditional teaching approach would suffice. Professors would be able to give a lecture or lesson; students would listen, take notes (if needed) and, when quizzed, be able to recite or transcribe any part of the lecture or lesson verbatim. Unfortunately, this is not the case; educational experts are continuously trying to find new solutions to improve educational teaching methods (Schank & Jona, 1991). Educational research has shown that students who are actively involved in the learning activity will learn more than students who are passive recipients of knowledge (Kumar, 2003). Using this research, many universities such as Wayne State are trying to bring active learning into the classroom using CRS (Barber & Njus, 2007). CRS is only one of many solutions to increase active learning in classrooms.

Clickers are used in education to combat student attrition, increase participation, and change the passive, one-way communication that is common in a lecture environment into an active, two-way communication between professor and student. Combating student attrition at NPS is not an issue because NPS is not a traditional university. Students at NPS are mandated to go to class; therefore, using clickers for this capacity is not required. On the other hand, clickers can be used to increase classroom participation by students at NPS.

A majority of professors at NPS use a creative approach to encourage student participation by incorporating a ten percent participation grade into their overall course grade. The participation grade is designed to motivate students to speak up during class by asking questions, stating their comments or opinions, telling the professor when they do not understand something, and essentially participate when appropriate. Numerous problems arise from this approach. First, classrooms of significant student size would suffer a reduction in the lecture time if everyone were to participate. That is, lectures are not long enough for everybody to speak their mind. Second, as Caldwell (2007) observes, "Students in classrooms are often hesitant or unwilling to speak up because of fear of public mistakes or embarrassment and fear of peer disapproval." Clickers enable students to voice their concerns in confidence. Unfortunately, situations exist where voicing one's concern in confidence can be counterproductive to the educational environment. For example, if a professor chooses not to address a student's concern, other students may be at a loss by not knowing the answer. Additionally, the students who choose to speak up often become the voice for the rest of the class. Finally, more simple solutions exist for combating low class participation than using CRS. For example, professors can ask the class to vote by raising their hands, clap, or use some other type of feedback to answer a question.

These simple solutions are not without their disadvantages. When students are asked to raise their hands, not wanting to feel like an outsider, fellow classmates will often raise their hands to follow the majority vote. Occasionally, students vote this way because they do not know the answer. Waiting to see how the majority votes and following their lead is the safest approach, because the few who decide to vote against the majority are typically asked by professors to explain why they voted the way they did. If these few do not know the correct answer, peer embarrassment is sure to follow.

To move from a passive state of learning to an active state of learning, students have to remain interested in what they are learning. How does a professor make lectures interesting and exciting to keep students' attention? Roger Schank and Menachem Jona believe "experience is the best teacher" and "the best teachers are typically the best storytellers" (Schank & Jona, 1991). Keeping students interested requires actions such as the professor telling relevant stories, having class discussions, participating in group activities, showing movie clips or even using CRS. No matter which course of action one takes, the professor must sacrifice lecture time, which is not always possible.

> A great many lecturers are reluctant to accept claims on the merits of activating instruction, which can be found in educational theory. Activating students requires time, which lecturers would normally devote to lecturing. They often voice the concern that they will not get enough

> material across when giving interactive lectures and that this consequently will negatively affect the student learning (Van Dijk, Van Den Berg, & Van Keulen, 2001).

Why should professors change their teaching methods now when they have worked for over 100 years? Traditional teaching practices using the passive learning approach have been used since the early 1900s (Schank & Jona, 1991). The problem is that the mission of the schools of the 1900s was primarily to train good factory workers, not well educated citizens (Apple, 1990). Many current teaching practices arose from technological factors and practical constraints that no longer apply (Schank & Jona, 1991). Clickers are an excellent example of how the tools of technology are shaping the educational future. With advances in technology, “students in the future will see a major restructuring of our social, industrial and educational institutions, and an increased reliance on computers for work and education” (Molnar, 1997). The difficulties in the road ahead lie in learning new technologies and getting professors, staff, and faculty to support the implementation of change.

CRS provide practical solutions to many of the issues caused by lack of participation, comprehension, and passive learning environments. First, when time constraints are of vital importance, CRS enable professors to poll small or large student size classrooms using CRS questioning, tally the responses, and display the results for discussion. This method allows professors to break up the monotony of long boring lectures by adding interactive solutions in which all students can participate. Second, professors do not have to discuss the results immediately; they have the choice to use these records later for cataloging attendance, student tutorials, lesson planning, or educational research (Caldwell, 2007). Lastly, clickers can be used to ensure comprehension of difficult concepts. Professors typically break complex concepts into subparts. Clickers can be used to test conceptual comprehension of individual subparts to ensure student comprehension before continuing. The danger in this approach lies in the hands of the professor. By not asking the right questions, CRS technology would have little impact on increasing comprehension.

3. Additional Insight

a. Student Motivation

Motivation has been described as a process that includes specific directive and stimulating properties (Brophy, 1987). This can lead students to arousal and instigative behaviors, give direction and purpose to their behaviors, allow behaviors to persist, and lead to choices of preferred behaviors (Dweck, 1986). A general pattern of student motivation toward learning often takes the following sequential form: student energy, volition, direction, involvement, and completion (Wlodkowski, 1978). If one area of student motivation breaks down, the entire process may come to a complete halt (Christophel, 1990).

Wlodkowski identifies five beliefs behind motivational theory that make the concept difficult to understand. These five beliefs reveal some of the challenges for measuring motivation in a classroom environment, which becomes further complicated when adding CRS. The five beliefs are as follows:

First belief: *When students are not willing to involve themselves in class activities or assignments, they are unmotivated.* Although students may not be motivated to learn, they are usually motivated to do *something*. If that motivation is not directed toward learning, it is likely to be directed toward disruptive behaviors (Christophel, 1990). CRS is designed to motivate students by creating a more active environment, but a more active environment sometimes requires increased teacher control. Increased teacher control, especially in larger classrooms, may be required to keep unproductive discussions to a minimum.

Second belief: *Teachers motivate students.* Although no one person can claim sole responsibility for motivating another person, teachers can make learning attractive and stimulating, provide opportunities and incentives, allow for development, and match student interests (Christophel, 1990). Motivating students is not a science.

Teachers must continue to find innovative ways and ideas to stimulate individual students. Obviously, the larger the class size, the more difficult this task becomes.

Third belief: *Since students must learn in order to survive, making them learn is more important than their motivation to learn.* If learning is associated with coercion it can become a generally aversive stimulus, one that students will go out of their way to avoid (Christophel, 1990). Forced learning or guided learning is necessary to some degree. Students must be challenged, not forced or coerced to learn more. CRS is a tool in which teachers can challenge students to compete against one another and offer rewards for specific behaviors.

Fourth belief: *Threats can facilitate student motivation to learn.* As military officers and senior DoD employees, threats are not necessary at NPS. The majority of the population realizes that failure at NPS will have an adverse effect on their existing careers; therefore, their motivation to succeed is higher than younger traditional college students. Using threats only stimulates students to become frightened and resentful of the threats and the person using them. The long term outcome is student avoidance of the teacher and the subject matter (Christophel, 1990).

Fifth belief: *Learning automatically improves with increased student motivation.* Motivation is not a panacea for instruction, but it may provide a foundation for effective instruction (Christophel, 1990). Students do not have to be motivated to learn. Often, students who do not like a particular subject will learn just enough to get by and stay unmotivated throughout the entire process.

Identifying the effectiveness of CRS as a motivational aid in the classroom is difficult. CRS provides students with feedback which can lead to educational reinforcement, but evaluators must comprehend Wlodkowski's five beliefs and understand how student attitudes in the classroom environment can affect motivation. A valid measurement must be created and evaluated to test motivation in CRS classrooms. Based on these concepts, the following research question was proposed:

Can motivation be used to improve student learning with clickers?

b. Student Engagement

Students' active engagement with ideas and applications supports learning. This view is most clearly advocated by Laurillard (Laurillard, 2002). The principle underlying this framework is that learning results in the process of ongoing and adaptive dialogue between teacher and student, supplemented by activities that provide an opportunity to apply ideas or practice skills (Simpson, 2006). Student engagement is one of the sure ways by which professors can guarantee students are actively learning. The problem with this approach is that only one student can participate through dialog with the professor at any given time in a traditional classroom environment, which becomes increasingly challenging with larger class sizes.

Knowing the difficulties to achieve 100 percent student engagement in larger class sizes during any given lecture, teachers still encourage participation from each student. One solution to overcome this difficulty is to divide classes into small-groups. Dividing classes into small-groups will grant each student an opportunity to participate within their group, thereby accomplishing the goal of 100 percent participation. Participation in small-group discussions primes students to be more attentive and involved in subsequent whole-class discussions (Beatty, 2004).

CRS can provide an additional aid to small-group discussions by giving each student a vote in the small-group's final response to a question presented by the professor. For example, suppose a particular class was presented with the question: is the earth round or flat? The class would be divided into small-groups for discussions among group members to formulate an answer. Once small-groups have formulated their answers, each student would select the appropriate answer by using their clickers. Responses would be rapidly tallied and displayed on the overhead projector. The professor could quickly identify incorrect answers and address any misconceptions. By having students communicate their knowledge and reasoning, in small-groups and through class-wide discussion, CRS can help them sharpen their vocabulary, clarify their thinking, discover gaps and contradictions in their understanding, and identify flaws in their logic (Beatty, 2004). Although a novel idea, small-group discussions are time consuming and not always possible.

By their nature, CRS engage all students in classroom instruction by allowing all the students to respond to every question asked by the teacher. Additionally, students can use the CRS as opposed to raising their hand to let teachers know they do not understand the material being taught or have a general question. The idea behind CRS is not new—teachers have used interactive, instructive questioning to engage students since at least the time of Socrates (Caldwell, 2007). CRS allow students to become engaged in classroom discussion through an interactive education without the fear of being singled out. CRS does not prevent students from using traditional means of communication such as raising their hands to ask a question or voicing that they do not understand a particular idea. Based on these concepts, the following research question was proposed:

Can student engagement be used to improve student learning with clickers?

c. Teacher Immediacy

Several studies have been conducted that analyzed the use of teacher immediacy behaviors (Christophel, 1990). Immediacy is the use of communication behaviors to enhance closeness between communicators (Mehrabian, 1969). Unfortunately, studies have not been conducted to research whether teacher immediacy can be used to analyze the effectiveness of student learning with clickers in the classroom.

The applications of immediacy to educational settings introduced the idea that a teacher, through the use of certain cues, could reduce the perceived distance between instructor and learners and thereby influence certain classroom outcomes, especially student learning (Allen, 2006). CRS facilitate reducing perceived distance between instructor and learner by creating active, rather than passive, two-way communication channels. Using teacher immediacy as a measuring tool to evaluate the effectiveness of CRS in the classroom is important because teacher immediacy represents a set of behaviors that an instructor can be trained to exhibit and/or increase. If a teacher's immediacy behaviors predict the level of student learning, then a modification of instructional communication behavior increases the level of learning (Allen, 2006). By uncovering the importance and effects of teacher immediacy in CRS classrooms, teachers can modify their immediacy behaviors to increase active learning in CRS classrooms.

Teacher immediacy can further be broken down into verbal and nonverbal aspects. Nonverbal teacher immediacy includes behaviors such as smiles, nods, body posture, gestures and eye movements. Results revealed a significant relationship between these teacher nonverbal immediacy behaviors and students' affective learning (Witt, 2004) The use of clickers may detract from nonverbal teacher immediacy because implementing clickers in the classroom adds another media device which will require students' attention. This additional requirement will decrease time spent by students focusing on the teacher, therefore decreasing nonverbal teacher immediacy. A safe assumption can be made that CRS will reduce nonverbal teacher immediacy.

Verbal immediacy received little attention in instructional communication research until Gorham (1988) reported a moderate correlation between verbal immediacy and both perceived and affective learning outcomes (Witt, 2004). Verbal immediacy includes but is not limited to behaviors such as addressing students by name, using humor in the classroom, discussing personal experiences, and asking or answering questions. For all of these behaviors, CRS can be used to modify the classroom environment to increase vocal expressiveness.

Together, verbal and nonverbal immediacy behaviors that a teacher displays in communicative acts and interactions with students can be seen as rewarding. These rewarding behaviors may serve as reinforcement for the attentive behavior, feedback, and interaction from the student that increases affective, cognitive, and behavioral learning (Allen, 2006). Implementing CRS as an interactive tool in the classroom environment will increase the will of students to approach and engage in the educational discussions that are critical to the learning process. Based on these concepts, the following research question was proposed:

Can verbal and nonverbal immediacy be used to improve student learning with clickers?

D. USES AND CHARACTERISTICS OF CLASSROOM RESPONSE SYSTEMS

CRS can be used in virtually any size classroom. Due to the rationale for their creation, to make up for a lack of teacher-student interaction in the classroom, the preferred use for CRS is in classes ranging from 15 students to more than 200 students (Draper & Brown, 2002). The first case studies of CRS were predominantly from physics professors. Now, case studies can be found in almost every area of education from business to medical institutions. Additionally, CRS are being used not only by universities, but also in elementary and K-12 settings (Johnson & McLeod, 2005). The focus of this study will be on a university environment.

Professors have one of two options when preparing questions to be used in class with CRS. First, the advised approach is to prepare questions to be used in the lecture slides during the lesson plan. Second, CRS provides teachers with the ability to create questions "on-the-fly" (*Renaissance Learning*, 2007). That is, during the lesson plan, if an important concept comes up that the professor wants to make sure is understood by the entire class, the professor can simply test the entire class by pausing and typing the question using the CRS software. Note that the first option is preferred, because taking time to prepare well-thought-out questions better ensures that students are grasping important concepts (Caldwell, 2007).

Varying views are found among CRS experts on how many questions a professor should ask his or her class during a 50-minute class period. Typically, between two to five questions are given per 50 minutes of class instruction (Burnstein & Lederman, 2001). Using this rule of thumb, professors can properly format their lectures so that they are not taken over by excess usage of CRS.

Once a professor chooses to use CRS technology, he or she should take some time before the semester or quarter begins to become familiar with how to set up and use the CRS. CRS software has a slight learning curve. New users should be sure to set aside some time to create class rosters and sessions with well developed questions (Hoffman & Goodwin, 2006). Once one masters the software, the main challenge is developing effective questions. Practice makes perfect and saves time. The local IT departments should be able to install the software on the computer that the professor would be using for lectures. A good idea is to devote a laptop with the software that can be transported from one classroom to the next (Hoffman & Goodwin, 2006). Second, software tutorials are available through most major CRS companies, or a resident expert should be able to explain the basics. Adding questions is as simple as creating Microsoft PowerPoint slides for a presentation or creating transparencies to be used on an overhead projector.

On the first day of class, the professor should take some time and explain in what capacity clickers will be used during the semester or quarter and conduct a familiarization session with the class. Although these devices are fairly easy to use, professors should run through example questions to familiarize the class with the new technology and ease any “technophobia” that some students may have about an advanced technology (Berube, 2006).

The Question Cycle below (see Figure 1) is an excellent representation of how a question is sent by a professor, discussed by the students, displayed and discussed by the professor and, eventually, evaluated by the professor and revised, if necessary (Dufresne, Gerace, Leonard, Mestre, & Wenk, 1996; Wenk, Dufresne, Gerace, Leonard, & Mestre, 1997).

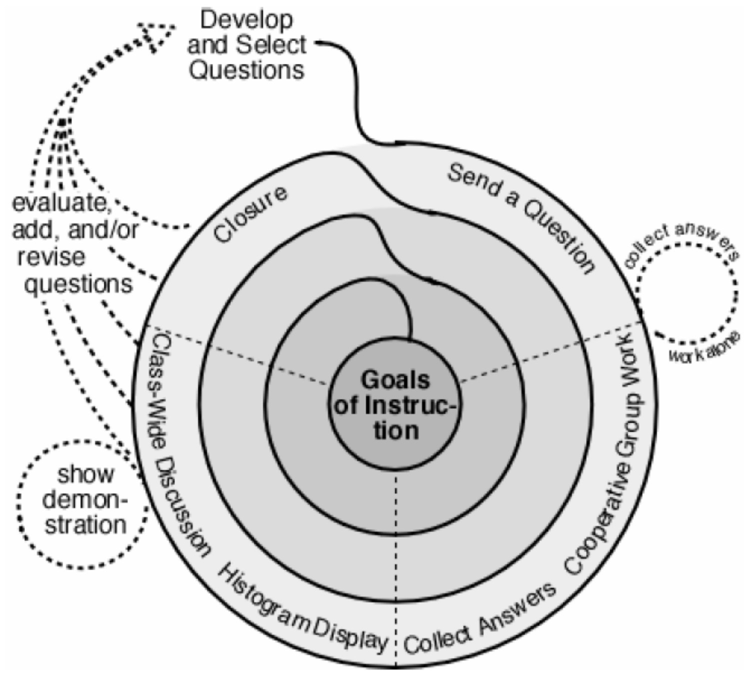

Figure 1. The Question Cycle—an Effective Model for CRS Use in Class [From Wenk, Dufresne, Gerace, Leonard, & Mestre, 1997]

The typical question format is as follows:

1. Professor sends a question to the class by Microsoft PowerPoint, overhead projector or writing the question on the screen.
2. Students take a few minutes to decide upon an answer either individually or in groups.
3. Students then enter their answer into their clickers.
4. Tallied responses are displayed on a projection screen.
5. Professor discusses the possible solutions and supporting evidence.
6. Correct answer is given.

With deft management, this process can be turned into a lively interchange of ideas and arguments between students. Instructors can follow up with a brief lecture on the relevant point (Beatty, 2004).

CRS have been used by professors in an assortment of ways. The following list outlines some of the more common uses by professors:

1. Attendance – Typically a non-issue at NPS, but difficult in the larger classrooms; if clickers were used, they would accelerate the process. The disadvantage is that the ID number on each clicker has to be mapped to an individual student.
2. Assessing understanding – Before the lecture starts, CRS can be used to assess the level of understanding of a particular topic, identifying areas that have already been sufficiently covered and highlighting sections in need of particular attention (Simpson & Oliver, 2006).
3. Initiating discussion – One of the main uses of CRS is to stimulate interest and initiate discussion (Simpson & Oliver, 2006). Professors question the class, giving ample time for students to talk among themselves before answering on their clickers.
4. Quizzes or tests – Reports of using clickers for summative high-stake testing are relatively rare. Quiz questions can check whether students are: comprehending the material, actively thinking or paying attention (Caldwell, 2007). Professors can also take a less direct approach and count the quiz grades for a small portion of the student's grade. For example, clicker quizzes at NPS will count for five percent of a student's participation grade.
5. Exercise problems – Professors could give short exercise problems during class to test comprehension.
6. Creation of community – At the beginning of a semester or quarter, CRS can be used to create awareness in a group or class. This can contribute to the forming of the group identity and support any future teamwork (Simpson & Oliver, 2006).

Like any technology, when used incorrectly, CRS can do more damage than good. CRS require professors to come up with innovative methods in designing questions that stimulate active learning. As Draper, Cargill, and Cutts (2001) observe:

> Instructional design mostly is not in the equipment or software, but in how each teacher uses it. That is a lesson which perhaps the rest of the learning technology field should take more to heart if the aim is in fact, to improve learning rather than to promote the glamour of machines.

For example, creating questions that are too simplistic can give professors the false belief that students comprehend a complex concept. This can be troublesome if the professor continues to the next topic, leaving the class confused. Professors can incorporate a failsafe mechanism for comprehension issues through the use of clickers. For example, the professor can enable a button on the clickers, so that when pressed by students, an alert message would appear on the professor's PC notifying the professor a student has a problem with comprehension. This would be similar to students raising their hands, but by using clickers, the student's anonymity would be protected. If multiple students respond in this manner at a particular point in the lecture, the professor can choose to either address the comprehension issue immediately or wait until later for further explanation.

E. COMPARISON AND ANALYSIS

Computer response systems (CRS) offer a variety of functions. As with other factors, the educator must determine the best capacity in which CRS suits needs within the class by choosing the functions it requires. Amid the numerous models, this study compares and analyzes five CRS models that use radio frequency (RF) technology. The following models were selected for their popularity among major universities: Qwizdom, Renaissance, eInstruction, Interwrite PRS, and TurningPoint. For a comparative analysis of these popular models, refer to Table 1 (pages 24-25). Each of these brands was compared on various characteristics: response capabilities, system requirements, and overall functionality.

Keypad design is one of the most critical characteristics for students using CRS. Students are often concerned whether their responses to questions were even transmitted to the receiver. Qwizdom, Renaissance, eInstruction, Interwrite PRS, and TurningPoint models all have LCD screens, which help students know that their answers were submitted. Using TurningPoint, students can input fractions, decimals, and negative numbers, and they receive instant right/wrong feedback on each device (*Turning Technologies*, 2007). This immediate feedback is a vast improvement from the earlier models that lacked a screen and only offered basic answer response methods.

Although earlier CRS models only had the capabilities for students to answer yes/no, true/false, or A/B questions, this is no longer the case. The eInstruction clicker allows for numeric entries of up to 12 characters that can be entered and viewed on the three-line LCD screen. The symbol button makes it easy to answer higher-level math and science questions (*eInstruction*, 2007). Interwrite PRS leads the other CRS with their nine different types of answer choices: multiple choice, true/false, yes/no, numeric, short answer, multiple correct, rank order, decimal point, and fractions (*Interwrite Learning*, 2007).

Each of the systems evaluated is compatible with Windows and Macintosh operating systems. One CRS stands out from the rest in operating system compatibility. In addition to being compatible with Windows and Macintosh operating systems, the Interwrite PRS system is also compatible with the Linux operating system (*Interwrite Learning*, 2007). Although Linux is not as popular as Windows or Macintosh, universities using Linux will not have to spend much time narrowing their choices on selecting their CRS of choice. These fortunate few universities only have one option, the Interwrite PRS.

In addition to working with Microsoft Office PowerPoint, some of the companies have developed software packages to better adapt their product to subject-specific courses. Qwizdom, for example, has a program called Qwizdom Actionpoint, which is an easy-to-use toolbar that fits comfortably within Keynote or Microsoft Office PowerPoint. This allows the user to instantly create an interactive slide presentation, view response graphs, play media files, and control the entire presentation with the Qwizdom presenter remote (*Qwizdom*, 2007). TurningPoint created a bundle called TurningPoint AnyWhere software. AnyWhere polling application uses the same functionality as TurningPoint through a floating toolbar that allows users to poll from content in any PC application, including web browsers, PDFs, Word documents, Blackboard, and more (*Turning Technologies*, 2007). One drawback of the separate program is the screen requirement the “floating” window takes up that often blocks a portion of the presentation material (Barber & Njus, 2007).

The implementation of classroom response systems allows a lecturer to record the data collected from each student to evaluate the student’s progress. Each CRS provides a different report system, but all record answers (Barber & Njus, 2007). In addition to being a CRS with several response methods, the Renaissance doubles as a calculator and can store information (homework assignments and notes). The large LCD screen with seven lines of text allows students to view entire questions at one glance without having to scroll down small screens with only one or two lines of text, which is a common characteristic among other CRS (*Renaissance Learning*, 2007).

Cost is a function that is very difficult to measure with these systems, because the models examined vary drastically in both functions and software availability. A lower cost Interwrite PRS clicker costs around $30 for orders of 100, whereas the Qwizdom Q4 Handheld is upward of $122 per unit (*Renaissance Learning*, 2007). Discounts can typically be obtained by buying clickers in bulk. Pricing per CRS depends on requirements and needs of the buyer’s organization.

When purchasing the CRS of choice, manufacturers rely heavily on customizing their CRS for individual users to establish a relationship for further business. Manufacturers will send representatives or sales consultants to greet the buyer and sit down and discuss the buyer’s requirements. Typically, this should be a person from the buyer’s organization who is knowledgeable about organizational IT specifications and limitations, as well as the educational needs and requirements of the organization. Upon reaching an agreement about which CRS will be purchased, including how many clickers, receivers and associated software packages are required, a cost can be determined; at that point, the sales consultant can offer a price. Therefore, comparing total costs is a very difficult process, because actual costs are dependent on the needs and requirements of the buyer’s organization.

Due to NPS's unique education system with various types of classrooms and material being taught, the CRS must be dynamic to meet the professors' needs. For this reason, the CRS with the most diverse software package is recommended. TurningPoint CRS is the best choice, based on the results from this comparison and analysis.

TurningPoint CRS has many strong features. First, TurningPoint integrates fully into the Microsoft Office Suite, including PowerPoint, Word, Excel and even Outlook. TurningPoint's integration with Microsoft Office PowerPoint gives trainers and presenters the ability to author, deliver, assess and report without having to leave PowerPoint (*Turning Technologies*, 2007). Secondly, TurningPoint CRS easily allows professors the ability to monitor how their classes are responding to questions to determine if more time is needed on a specific topic. Finally, finding a CRS that seamlessly integrates into existing NPS technology architecture such as Blackboard, Microsoft Office Suite and the more popular educational publishers such as Thomson Learning and Glencoe/McGraw Hill is extremely important (*Turning Technologies*, 2007). Although their LCD screens are large, a major disadvantage of TurningPoint CRS is the limited two lines of text.

Despite different schools of learning and faculty members preferring different models, it is important that NPS select a single CRS manufacturer. NPS needs to learn from the mistakes of other universities when purchasing multiple CRS and being forced to standardize to one manufacture at some later time. Creating a committee with representatives from each of the major schools of learning is the recommended approach used by other universities such as Ohio State University. Ohio State University put together a CRS committee to perform the following actions:

1. Define the key educational goals.
2. Propose technical solutions and evaluate costs.
3. Discuss policies, procedures and guidelines for "clicker" deployment (Metros, 2005).

By using a single CRS manufacturer such as TurningPoint, faculty and students can adapt faster to using the system, technical support requirements can become uniform, creating a strong in-house support system (Barber & Njus, 2007), and costs can be reduced. NPS students can be trained to use one standardized CRS during their indoctrination week. This would enable students to develop their knowledge base of clickers to enhance their educational experience.

Table 1. A Comparison of Different Classroom Response Systems [From Bhuta, 2006]

	Manufacturers				
Features	**Interwrite PRS**	**eInstruction**	**Qwizdom**	**TurningPoint**	**Renaissance**
Type	Radio frequency	Radio frequency	Radio frequency	Radio frequency	Radio frequency
Computer System Compatibility	Windows or Mac or Linux	Windows or Mac	Windows or Mac	Windows or Mac	Windows or Mac
LCD Screen	Yes. Two lines of text.	Yes. Three lines of text	Yes. One line of text.	Yes. Two lines of text.	Yes. Seven lines of text.
Communication Range	150 ft.	200 ft.	1000 ft.	200 ft.	150 ft.
Units per receiver	Up to 2047	Up to 1000	Up to 1024	Up to 1000	300
Battery	3 AAA batteries	2 AA batteries	2 AA batteries	2 coin cell batteries	2 AA batteries
Battery Life	Up to 20 weeks	360 hours	Up to 12 months	Up to 12 months	Up to 12 months
Instructor control	Keyboard/mouse	Keyboard/mouse	Instructor remote	Keyboard/mouse	Keyboard/mouse
Presentation Software	Limited PowerPoint Integration	PowerPoint	PowerPoint	PowerPoint, Turning Point	PowerPoint/AccelTest
Student device displays feedback	Blinking light	Blinking light	Alphanumeric display	Blinking light	Blinking light
Supports paper-based testing	Yes	No	Yes	No	No

Table 1. (continued)

	Manufacturers				
Features	**Interwrite PRS**	**eInstruction**	**Qwizdom**	**TurningPoint**	**Renaissance**
Question types available	**9 types:** Multiple choice, T/F, Yes/No, numeric, short answer, multiple correct, rank order, decimal point, fractions	**7 types:** Multiple Choice, T/F, Yes/No, Rating Scale, Numeric Decimal/fraction	**7 types:** Multiple Choice, T/F, Yes/No, Numeric, multiple-mark multiple choice, rating scale, sequencing	**6 types:** Multiple Choice, T/F, Yes/No, Rating Scale, Numeric, Decimal	**6 types:** Multiple Choice, T/F, Yes/No, Numeric, Decimal
Publishers using (This list keeps on changing)	Pearson Group Allyn & Bacon Thomson Wiley, Worth W. H. Freeman	Pearson Group McGraw-Hill Pearson	Pearson Group Wiley	Pearson Group Thomson	McGraw Hill, Prentice Hall School, Glencoe
Gradebook feature	Yes	Yes	Yes	Yes	Yes
Student cost/unit	$30 (orders of 100+) No access code	$3 Access code: $18/qtr	$50-$122, dep. on volume. No access code	$50, dep. on volume. No access code	$79.99. No access code
University cost	Varies, depending on Publisher agreement				
Website	http://www.interwritelearning.com	www.einstruction.com	www.quizdom.com	turningtechnologies.com	www.renlearn.com

II. SYSTEM REQUIREMENTS AND RENAISSANCE CRS SOFTWARE FUNCTIONALITY

A. SYSTEM REQUIREMENTS

NPS purchased the Renaissance Classroom Response System, as it contained the hardware and software that best met NPS needs. Inside each Renaissance Classroom Response System carrying case is the following software packages and instructions: AccelTest version 1.0 (CD), 2KnowToolbar version 1.0 (CD), and online training instructions. Additionally, every system includes a wireless receiver, USB cable to connect the wireless receiver to a PC, and 24 Renaissance Responder handheld remote units or clickers. Finally, each case includes user manuals and the necessary access codes to register the equipment and download updates, patches, and utilities.

The Renaissance Classroom Response System operates on Windows or Macintosh. The system requirements for these two operating systems are as follows:

Table 2. Renaissance CRS System Requirements for Windows and Macintosh [From *Renaissance Learning*, 2007]

Windows	**Macintosh**
Processor: Pentium P3 450 MHz or faster	Processor: Power PC G3 450 MHz or faster
Operating Systems: Windows 2000 or later	Operating Systems: System 10.3.9 or later
RAM: 128 MB physical RAM	RAM: 128 MB physical RAM
Hard Drive Space: 40 MB	Hard Drive Space: 40 MB
CD-ROM: Drive Required	CD-ROM: Drive Required
Pointing Device (mouse): Required	Pointing Device (mouse): Required

Renaissance Classroom Response System software must be installed on the PC to which the receiver is connected for the system to operate properly. Installation requires the receiver driver, which is included when installing AccelTest or 2KnowToolbar. All the classrooms at NPS in the Graduate School of Business and Public Policy (GSBPP) are configured with PCs at the front of the classroom that meet the necessary system requirements to run Renaissance. This includes the thin client server. Due to NPS's IT restrictions, contacting the IT department to load the Renaissance CRS software on school computers is required. Unfortunately, the CD for AccelTest version 1.0 is outdated. An updated version of AccelTest, presently version 3.0, can be downloaded from the Renaissance website, http://download.renlearn.com/us/search.asp?type=2. NPS's access code is required for the download and can be obtained from the GSBPP Director of Instructional Technology.

The Renaissance website, http://www.renlearn.com/Profdevel/PD/2Know_pd.aspx? type=ondemand&product=2know, provides an excellent step-by-step visual online tutorial on how to install the software. Additionally, the website provides specific step-by-step instructions and training on how to use AccelTest and 2KnowToolbar (*Renaissance Learning*, 2007). The website can also be used for those professors who choose to install the AccelTest or 2KnowToolbar (or both) on their personally owned PCs. After loading AccelTest on any PC, a PDF version of the user manual can be opened from the start menu.

B. RENAISSANCE CRS SOFTWARE FUNCTIONALITY

The primary difference between the 2KnowToolbar and AccelTest is the interface. The 2KnowToolbar is used for quick polling of the audience while AccelTest is a more formal assessment. The 2KnowToolbar is a floating toolbar that remains on top of other open software applications on the desktop of a PC. Three different types of questions can be asked using the 2KnowToolbar: true/false (T/F), numeric (123), or multiple choice (ABC). Student responses and answers can easily be displayed in a bar graph format on a projector screen for the class to view. Additionally, the toolbar provides a feature called "pulse," which allows professors to poll the class during a lecture, or students to use the yes/no buttons to register if they comprehend the material. Professors can use the feedback provided to either move on to the next topic or address the concept from another direction.

The advantages of 2KnowToolbar are that it is easy to install and requires little time to learn. With this software, clickers do not have to be assigned to individual students. The main disadvantage is that this software application does not record student responses. Recording student responses may be important if professors wish to review student responses at a later time to modify their lectures or for grading purposes.

AccelTest, a more advanced software application, provides the extra features that the 2KnowToolbar lacks. AccelTest allows professors to set up individual classes and create sessions to assign homework assignments, give quizzes, and even give formal exams. The grade book feature allows professors to keep track of individual student scores. The report feature allows professors to view and print a summary of students' grades, either individually or collectively as a class. Although AccelTest would be installed on lecture podium PCs in Ingersoll, transferring the data from the classroom PC to a personally owned PC can become tedious and time consuming. An alternative is for professors to install and use AccelTest from their personally owned PCs. This will require professors to connect their personally owned PCs through a VGA connector to the classroom overhead projector for each class they wish to use AccelTest.

The advantages of AccelTest is that it helps professors create questions and answer choices that can be viewed on students' clickers, which include an easy scroll feature that accommodates longer questions. This eliminates the need for paper, projector, or TV. Using AccelTest, professors can create a nearly endless supply of reusable quizzes, tests, and other exercises to assess students' performance in virtually any subject. With AccelTest, professors save time by automating assessment scoring with results recorded immediately to the grade book. As a result, professors spend less time on paperwork and record-keeping tasks (*Renaissance Learning*, 2007).

AccelTest does not come without its disadvantages. First, the software application takes time to become familiar with the features and functionality, which may discourage its use by busy professors. All assignments, quizzes, and tests have to be inputted into the software application, which can also be time consuming. Second, clickers have to be assigned to individual students. Therefore, professors must let the students keep the clickers in their possession or clickers must be collected and redistributed to their assigned owner for each class. When professors utilize the homework assignment feature students must retain the clickers. This feature enables students to take the clickers home and complete homework assignments on their own time. When students bring their clickers back to class, the clickers are synchronized through the receiver to AccelTest and homework assignments are downloaded from the clickers to AccelTest and automatically graded. Results are viewed in the grade book tab or in the reports drop-down menu.

III. METHODOLOGY

A. PARTICIPANTS

Participants were 41 students enrolled in a graduate information technology (IT) course at the Naval Postgraduate School. The course is designed to make students more effective IT users and decision makers, and help them recognize opportunities where the application of IT solutions can provide a strategic advantage. These objectives are met by providing students with a broad overview of computer technology, information systems, database/knowledge management, networks, and information security. As a first-quarter course, it was the first traditional classroom course in several years for many of the enrolled students.

Participants ranged in age from 27 to 50 years old (M = 33.02, SD = 5.36), and 37 were male (90.2%). Participants included two civilians (4.9%), 13 international military officers (31.7%), and U.S. military officers (63.4%) with the following ranks: 12.2% were O2, 51.2% were O3, 24.4% were O4, 4.9% were O5, and 2.4% were O6. Participants identified themselves as African-American (4.9%), Asian (7.3%), Caucasian (56.1%), Hispanic (12.2%), or “other” (7.3%), and 7.3% declined to report their race/ethnicity.

B. DESIGN

The current study employed a posttest-only independent groups quasi-experimental design to test the effects of clickers in the classroom. Specifically, two sections of the IT course were included in the study, and the researchers chose one section randomly to serve as the experimental classroom, and the other to serve as the control classroom.

Each student in the experimental classroom was given a Renaissance Responder (clicker) at the beginning of each lecture period and asked to log into the 2Know! Session (clickers were not assigned to specific students). To avoid the novelty of the response system impacting the outcomes of interest, the clickers were used in the experimental classroom for two weeks prior to data collection to resolve technical difficulties and condition students to the technology. During this period, the students were trained how to use the clicker and were able to ask questions until each student felt comfortable with the technology. The students in the control group were not issued clickers or introduced to the technology.

C. PROCEDURE

Throughout the ten-week quarter, student interactions were observed in both classrooms. The total number of student interactions that occurred each hour during nine randomly selected two-hour class sessions resulted in an hourly interaction score. Individual student scores were not recorded. An interaction occurred when a student participated in one of the following ways: raising of hand, answering a question (from the professor or another student), asking for further explanation, or responding with the pulse function of the clicker (test group only). Only voluntary interactions were recorded and all "polling" questions to the class were excluded from the interaction score (because this interaction was instructed by the professor).

When the clicker's pulse function was used in the experimental classroom, students would indicate if they understood the concept(s) being presented by the instructor (a positive response) or did not understand (a negative response). Students were instructed that they could respond as many times as they liked (e.g., they could change from a negative response to positive response if the issue was resolved). If the pulse data indicated that the concept was still unclear (e.g., most responses were negative), the instructor asked students to explain what questions existed (if a student responded to this question, it counted as an interaction). After a course concept was presented in full and the instructor observed a large majority of responses, the results from each "pulse window" were evaluated. After any issues were resolved, the pulse function was reset to zero (i.e., all pulse data would be erased and students could begin the process again on the next course topic).

In addition to tracking interaction scores, students in both classes completed a survey. After providing informed consent, participants completed items to measure student motivation, perceived teacher immediacy, course liking, and levels of student engagement. Additionally, the experimental group completed items to assess their beliefs about clickers, and answered open-ended items where participants provided comments and suggestions regarding the clickers. Finally, both groups completed demographic items.

D. INSTRUMENTATION

Measures were scored such that higher scores indicated greater perceptions of the construct being measured (see Appendix for measures). Given that specific items were specified a priority to measure only one factor, confirmatory factor analysis was employed to test the measurement model (Anderson, Hunter, & Gerbing, 1987; Hunter & Gerbing, 1982; Levine, 2005). The data was found to be consistent with the proposed factors. Internal consistency tests showed that the errors calculated between items measuring the same construct were within sampling error of zero. Likewise, the parallelism test indicated that the errors calculated between items measuring different constructs also were within sampling error of zero.

Course liking. Five 7-point Likert-type items taken from Jackson and Trees (2003) measured students' liking of the course. Student-reported course liking had a mean of 6.04, (SD = 0.84, α = .95).

Overall evaluation of clickers. Respondents in the test group completed 12 7-point Likert-type items modified from Fitch (2004) and Greer and Heaney (2004) designed to measure student evaluations of clickers. This scale included items such as "Using the clicker added interest to the class" and "The clickers increase interaction in the classroom." Overall clicker evaluations had a mean of 5.13, (SD = 1.42, α = .97).

Perceptions of clicker usefulness. Participants in the experimental group completed four 7-point Likert-type items designed to assess the degree to which students perceived the clicker's functions to be useful. Perceptions of clicker usefulness had a mean of 5.44, (*SD* = 1.49, α = .98).

Perceptions of function liking. Participants in the experimental group completed four 7-point Likert-type items designed to assess the degree to which students liked the clicker's functions. Liking of clicker functions had a mean of 5.38, (*SD* = 1.51, α = .97).

Interaction score. The total number of responses (i.e., hands raised, clicker response, verbal response) during each class hour were summed to create the interaction score. Student interaction scores ranged from 0-17 per hour and had a mean of 8.17 (*SD* = 5.51).

Student motivation. Twelve 7-point semantic differential items taken from Christophel (1990) were used to measure student motivation. Student motivation had a mean of 4.92 (*SD* = 0.74, α = .91).

Student engagement. Four 7-point Likert-type items modified from Jackson and Trees (2003) measured the amount of student engagement. Students' self-reported engagement had a mean of 5.34, (*SD* = 1.08, α = .87).

Perceived teacher immediacy. Four 7-point semantic differential items taken from Kearney, Plax, Smith, and Sorenson (1988) measured student perceptions of teacher immediacy. Perceptions of teacher immediacy had a mean of 6.44 (*SD* = 0.78, α = .93).

Open-ended items. Respondents in the test group were asked to respond to two open-ended items designed to elicit general feedback about their clicker use. Specifically, participants received the following instructions:

> Now we would like you to take a moment and provide any additional feedback you'd like to share about the clickers. Please feel free to comment on any aspect—likes, dislikes, any comments for future use.

IV. RESULTS

A. COURSE LIKING

Results indicated that the degree to which students using clickers liked the course ($M = 6.04$, $SD = .84$) differed significantly from students in the control group ($M = 5.34$, $SD = 1.36$), $t(39) = 2.04$, $p < .05$, $r = 31$.

B. EVALUATION OF CLICKERS

Because only students in the experimental condition were able to evaluate the clicker and its functions, a one-sample *t*-test was used to determine if students' evaluations were more favorable than the midpoint of the scale. Results indicated that students' overall evaluation of the clickers ($M = 5.13$, $SD = 1.42$) were substantially more favorable than the midpoint of the scale (4.00), as indicated by the large magnitude of the effect size, $t(23) = 3.89$, $p < .01$, $r = .63$.

C. EVALUATION OF CLICKER USEFULNESS

One-sample *t*-test results indicated that students rated the usefulness of the clicker's functions ($M= 5.44$, $SD = 1.49$) as substantially more favorable than the midpoint of the scale (4.00), as evidenced by the robust effect size, $t(23) = 4.72$, $p < .001$, $r = .70$.

D. EVALUATION OF FUNCTION LIKING

One-sample *t*-test results indicated that students rated their liking of the clicker's functions ($M= 5.38$, $SD = 1.51$) as substantially greater than the midpoint of the scale (4.00), as indicated by the large effect size, $t(22) = 4.38$, $p < .001$, $r = .68$.

E. INTERACTION SCORE

Results indicated that the total interaction scores for participants in the experimental group (M = 9.33, SD = 7.16) did not differ substantially from those in the control group (M = 7.00, SD = 3.20), $t(16) = 0.89$ p = .39, r =.22.

Results indicated that the number of hands raised each hour in the experimental group (M= 4.33, SD = 2.35) did not differ significantly from the number of raised hands in the control group (M = 7.00, SD = 3.20), $t(16) = -2.02$, p =.06, r = -.45.

F. STUDENT MOTIVATION

Independent sample *t*-test results indicated that student motivation for students using clickers (M = 4.92, SD= .74) did not differ significantly from students in the control group (M = 4.68, SD = 1.46), $t(36)$ = .67, p= .51, r = .11.

G. STUDENT ENGAGEMENT

Independent sample *t*-test results indicated that student engagement for students using clickers (M = 5.34, SD = 1.1) did not differ significantly from students in the control group (M= 5.0, SD = 1.4), $t(39)$ = .97, p = .34, r = .15.

H. PERCEIVED TEACHER IMMEDIACY

Independent sample *t*-test results indicated that perceived teacher immediacy for students using clickers (M = 6.43, SD = .77) did not differ substantially from students in the control group (M = 6.37, SD = .82), $t(39)$ = .28, p = .78, r = .04.

I. OPEN-ENDED ITEMS

The experimental group responded favorably to the clickers through the open-ended survey questions. Student feedback indicated that the clicker helped in learning the material, focusing the class, and gauging individual levels of understanding. The feedback also indicated that the clicker was viewed as both a useful teaching and learning tool and should be implemented in additional courses. Students identified some clicker limitations and made recommendations for further implementation at NPS. Among these recommendations: using them in “a more concerted effort…would improve its effectiveness” and “the professor needs to be more interactive with [the] clicker.” In addition to the usefulness of the clickers, students described the clickers as a “fun learning tool and interactive experience.”

In addition to the clickers increasing course liking, the students found the clicker to be useful. One reoccurring theme from the open-ended survey responses was that the usefulness of clickers decreased when the technology was not working properly due to user errors. Students suggested that the instructor should understand the clicker system fully before using it in class, because it was distracting when time was taken to troubleshoot the system.

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V. DISCUSSION

The evaluation of clickers in the classroom was done primarily to determine if interaction was increased. Interaction is crucial in classrooms, because increased interaction is linked to increased learning. Past studies report that students learn in a myriad of ways and it is up to the instructor to promote as many means to transport the material to the students as possible. This study examined how clickers affect students with the following research questions:

Q1: Do clickers increase course liking?

Q2: How do students evaluate the clickers?

Q3: Do students find clickers useful?

Q4: What functions do students like?

Q5: Do clickers increase classroom interaction?

Q6: Do clickers increase student motivation?

Q7: Do clickers increase student engagement in the course?

Q8: Do clickers increase perceived teacher immediacy?

The results of the study conclude that the implementation of clickers in a classroom increased course liking. Students found the clicker functions to be both useful and favorable. In addition, although not proven statistically, data values indicated positive correlation between clickers and increased participation. The study failed to conclude that clickers increase student motivation, perceived teacher immediacy, and student engagement.

A. COURSE LIKING

Results indicated that the degree to which students using clickers liked the course differed significantly from students in the control group. Not unlike past studies, the implementation of the clickers proved to increase the liking of the course (Abrahamson, 1999).

Some of the reasons for this increase include the greater amounts of interaction and feedback. Through addition of the clickers, students had means to communicate to the professor their levels of understanding, so that the rate of material could be adjusted accordingly. Additionally, the clickers facilitated another method for students to communicate to the instructors and classmates.

The increased communication in the experimental group may have given the participants an increased feeling of learning. Knowledge is constructed in response to interactions with others (Brown, 1989). Through interactions with classmates and professor, and having immediate feedback given through the clickers, individuals were given many methods to actively learn, increasing their knowledge base. Despite the implementation of clickers, which could reduce verbal communication, the instructor used the responses as a launching point for further discussion. After students responded, the instructor asked if someone would want to explain how they came to the correct answer. To ensure the majority of the class was on the same level, a second question was posed to ensure everyone had better understanding of the material.

B. EVALUATION OF CLICKERS, USEFULNESS, AND FUNCTIONS

Students reported that all functions of the clicker were useful. Through data obtained from experiment participants, it was concluded that the numeric response was the top function (in both usefulness and liking). This response was somewhat unexpected; however, this feature added significant value in answering IT-related questions. Rather than the students getting two minutes to work through a problem and then revealing their answer to the entire class one by one (with the ability to change their answer if others are not reporting it), all students were able to work through at the same time and report their answer. The instructor kept the inputs hidden until all had answered or time was called. Not only did this save time in the class, it also allowed students to work through the problem without being influenced by other answers.

Despite the statistical report stating that the clickers were useful and beneficial, some participants were adamantly against the technology. According to one survey the “clickers were not used in any type of profound way that advanced the educational process.” Some students also felt that their infrequent use slowed the progress of the class. Although the technological glitches affected the entire class, students were free to do as they wanted. The technology allows those who benefit from the clicker to participate, and those who do not to decline. The students in the latter group can rely on the traditional methods of interacting within the class if they so prefer.

1. Interaction Score

The difference between the experiment and control group interaction scores was not statistically significant. However, the means were in the direction of hands raised in the control group, and although the significance test did not meet the necessary threshold, the effect size is substantial; it is likely not significant simply due to the meager sample size. The researchers of this study hypothesize that with additional testing, with a larger sample size, the difference would be significant. The experimental group interacted more with the clickers ($M = 9.33$) versus hands alone ($M = 4.33$). This increase could be for several reasons. First, with a clicker the student has an additional way to interact. Second, when using the clickers the students are given immediate feedback through viewing of everyone’s response. This encourages participation when a question is posed to check their comprehension level. Third, when a question does arise, students can anonymously indicate through the clicker that something is unclear. Given the competitive nature of the students attending NPS, the clicker fosters healthy classroom competition by involving everyone in the process, even those who may not normally participate, without the fear of being singled out or answering incorrectly.

C. STUDENT MOTIVATION AND ENGAGEMENT

There was no significant difference between the experimental and control groups, indicating that the clickers did not affect student motivation or engagement. Despite the clickers being an additional method for the instructor to stimulate the students, no significant motivational differences were recorded. This does not, however, indicate that students were not learning (Christophel, 1990). The study took place in a Fundamentals of IT course. The format of the class consisted primarily of lectures, periodically broken up by questions allowing students to listen and take notes on the material. Students in the course typically took notes and memorized the concepts prior to the exams. Although they learned the material, they did not have to be highly motivated throughout the term, just motivated enough to learn the material for the exams.

Data did not produce a statistically significant difference between the groups, possibly attributing to the type of students participating in the study. Past studies primarily implementing the technology in undergraduate courses indicate that clickers increase motivation and engagement (Trees, 2007). Students at NPS are highly motivated individuals. The students are at NPS due to their military successes and academic achievements. Due to the nature of the school, most of the students realize that failure to succeed will have negative implications on their career. Given the nature of the participants and the incentives to do well, and the high scores reported for these survey questions, a ceiling effect is possible.

Student engagement is also not very difficult at NPS, as most class sizes are under 30. Despite this small class size, there is still only one instructor who must encourage participation from each of the students. Again, due to the nature of the study participants, many do not have problems engaging in the class discussion and actively participating. At NPS. However, there is a different aspect of participation that is not commonly seen in traditional universities: rank. As a military institution, officers are sent at various times of their career. Typically officers attend NPS at the O-3 level; however, in this study O-3 ranking officers made up approximately 51% of the participants. The other participants included O-4 (24%), O-2 (12%), and a small number of O-5, O-6, and civilians. One of the goals at NPS is to prevent rank from impacting learning in the classroom; however, since the hierarchical structure is ingrained heavily in each of the officers, it is often difficult to separate from it when in the classroom. On occasion, during course discussion lower ranking officers will cease to speak their opinion when a higher ranking officer voices another opinion. The clickers are able to reduce this aspect further by allowing opinion polls to be taken anonymously.

D. PERCEIVED TEACHER IMMEDIACY

Results indicated that perceived teacher immediacy did not differ from students in the control group. Due to the similarity of scores from each group, the clickers did not affect the perceived teacher immediacy. The scores given by both groups were extremely high. These results indicate that the instructor exhibited verbal and nonverbal immediacy behaviors. High levels were reported, even with the experimental group where it was hypothesized that nonverbal immediacy would be lost. These results suggest that, in this test, the professor uses more verbal immediacy than nonverbal. Classroom observation of the class revealed that humor and personal stories were weaved into the lectures. The instructor also knew the majority of students by name and encouraged interaction throughout the class.

The instructor's high immediacy score not only enabled students to communicate further with the instructor, but also affects the learning outcomes (Witt, 2004). Although how immediacy increases learning has not yet been agreed upon, past studies have proposed several explanations. Christophel (1990) proposed that immediacy increases the student's motivation to learn, which increases learning. Immediacy may attract student attention, which is related to cognitive learning (Comstock, 1995).

E. LIMITATIONS OF THE STUDY

Through the course of the study, it was determined that further testing is required to determine the how to achieve maximum benefit of the clickers. Additional tests suggested by the researchers are: different types of course material, larger sample sizes, more consistent use, and even use of all function capabilities. Another factor that should be better controlled are the technical difficulties, both technology and user, which distract from the course.

F. RECOMMENDATION

As seen through this study, clickers will not immediately increase student engagement. In fact, how the clickers impact the course depends directly on how the students respond to and use them (Trees, 2007). The implementation of clickers can potentially reform the classroom, by increasing course liking and interaction. The attitude toward the clicker is an important factor when considering the introduction of the technology. Without student buy-in, clickers will not be used for participation and engagement levels may not be impacted.

Implementation of clickers allowed students to respond anonymously, perhaps increasing their liking of the course. Students are able to learn by working through and answering questions whereas, in traditional classrooms, they would not in fear of an incorrect answer. The clicker also allows for each student to answer the same question simultaneously, while keeping the results hidden until the instructor is ready to discuss the correct answer. This allows students to answer at their own pace without the temptation of giving the same answer as faster classmates. The quick reporting ability allows the instructors to know immediately the understanding levels in the course, rather than waiting for each person to report while going around the room.

APPENDIX

Course Liking

Read each statement and rate how much you agree or disagree with each of the following statements by circling a number. 1 means “very strongly disagree,” 4 means “neutral,” and 7 means “very strongly agree.”

1. I like this course.

Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

2. I am happy with this course.

Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

3. I think this course is good.

Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

4. I think this course is fun.

Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

5. I am pleased with this course.

Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

Evaluation of Clickers

Read each statement and rate how much you agree or disagree with each of the following statements by circling a number. 1 means "very strongly disagree," 4 means "neutral," and 7 means "very strongly agree."

1. I enjoyed using the clicker in class.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

2. Using the clicker added interest to the class.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

3. The use of the clicker helped me to learn class material better.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

4. The clickers helped focus the class as a whole on the subject.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

5. I believe the clickers should continue to be used in this class.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

6. I would like for other classes I have to use the clickers.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

7. The use of clickers helped me to gauge my level of understanding of course material.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

8. The clickers are fun to use.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

9. The clickers increase interaction in the classroom.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

10. Using the clickers is an effective teaching tool.

    Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

11. Using the clickers is an effective learning tool.

Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

12. Using the clickers increased my willingness to ask questions in class.

Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

Evaluation of Clicker Functions

Read each statement about clicker functions and rate how much you agree or disagree with each of the following statements by circling a number. 1 means “very strongly disagree,” 4 means “neutral,” and 7 means “very strongly agree.”

1. The *pulse reading* function of the clicker is useful.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

2. I like the *pulse reading* function of the clicker.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

3. The *multiple choice* function of the clicker is useful.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

4. I like the *multiple choice* function of the clicker.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

5. The *true-false* function of the clicker is useful.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

6. I like the *true-false* function of the clicker.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

7. The *numeric-response* function of the clicker is useful.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

8. I like the *numeric-response* function of the clicker.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

Student Motivation

Please circle the number that corresponds to the word that best describes how you feel in this class:

1. Motivated	1	2	3	4	5	6	7	Unmotivated
2. Interested	1	2	3	4	5	6	7	Uninterested
3. Involved	1	2	3	4	5	6	7	Uninvolved
4. Not stimulated	1	2	3	4	5	6	7	Stimulated
5. Don't want to study	1	2	3	4	5	6	7	Want to study
6. Inspired	1	2	3	4	5	6	7	Uninspired
7. Unchallenged	1	2	3	4	5	6	7	Challenged
8. Uninvigorated	1	2	3	4	5	6	7	Invigorated
9. Unenthused	1	2	3	4	5	6	7	Enthused
10. Excited	1	2	3	4	5	6	7	Not excited
11. Aroused	1	2	3	4	5	6	7	Not aroused
12. Not fascinated	1	2	3	4	5	6	7	Fascinated

Student Engagement

Read each statement and rate how much you agree or disagree with each of the following statements by circling a number. 1 means "very strongly disagree," 4 means "neutral," and 7 means "very strongly agree."

1. I actively participate in class.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

2. In this class, I am engaged in the classroom process.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

3. I often feel withdrawn during interactions in this class.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

4. In this class, the students discussed course material more seriously than in my other classes.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

5. I am actively involved in this class.

   Very strongly disagree 1 2 3 4 5 6 7 Very strongly agree

Perceived Teacher Immediacy

Please circle the number that corresponds to the word that best describes the teaching style of your teacher:

1. Distant	1	2	3	4	5	6	7	Close
2. Cold	1	2	3	4	5	6	7	Warm
3. Unfriendly	1	2	3	4	5	6	7	Friendly
4. Withdrawn	1	2	3	4	5	6	7	Outgoing
5. Restrained	1	2	3	4	5	6	7	Open

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